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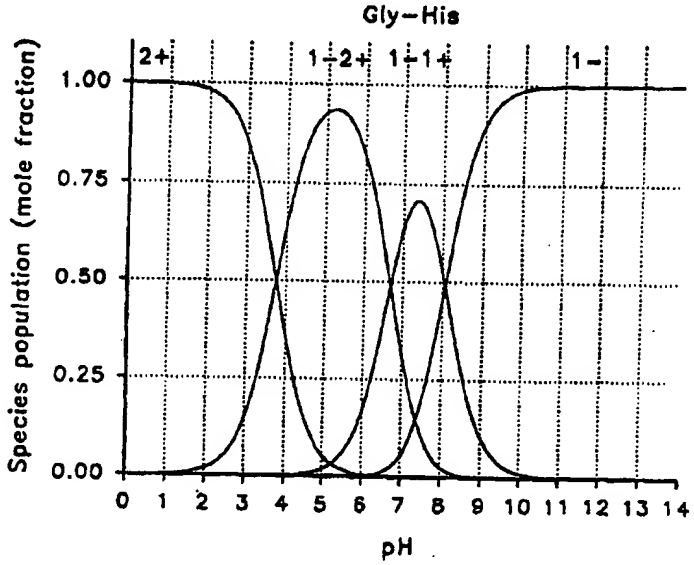
(54) Title: BUFFERED DRUG FORMULATIONS FOR TRANSDERMAL ELECTROTRANSPORT DELIVERY



(57) Abstract

Buffered drug formulations for transdermal electrotransport delivery are disclosed. The formulations utilize a dipeptide as a buffer and allow for more efficient electrotransport delivery of drugs, e.g., polypetide drugs, via the transdermal route.

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Claims:

1. A formulation for transdermal electrotransport delivery, comprising an aqueous solution of a drug or an electrolyte and a dipeptide buffer, the dipeptide buffer comprising a polypeptide chain of 2 to 5 amino acids and having an isoelectric pH at which the dipeptide carries no net charge, the dipeptide having at least 2 pKa's which are separated by no more than about 3.5 pH units, the solution having a pH which is within about 1.0 pH unit of the isoelectric pH.

2. The formulation of claim 1, wherein the isoelectric pH of the dipeptide is between about 3 and 10.

3. The formulation of claim 1, wherein the dipeptide is present in the solution at a concentration of at least about 10 mM.

4. The formulation of claim 1, wherein the dipeptide includes at least one amino acid selected from the group consisting of His, Tyr, Arg, Cys, Lys, Asp and Glu.

5. The formulation of claim 1, wherein the dipeptide includes His.

6. The formulation of claim 1, wherein the dipeptide is Gly-His.

7. The formulation of claim 1, wherein dipeptide is selected from the group consisting of Asp-Asp, Gly-Asp, Asp-His, Glu-His, His-Glu, His-Asp, Glu-Arg, Glu-Lys, Arg-Glu,, Lys-Glu, Arg-Asp, Lys-Asp, His-Gly, His-Ala, His-Asn, His-Citruline, His-Gln, His-Hydroxyproline, His-Isoleucine, His-Leu, His-Met, His-Phe, His-Pro, His-Ser, His-Thr, His-Trp, His-Tyr, His-Val, Asn-His, Thr-His, Try-His, Gin-His, Phe-His, Ser-His, Citruline-His, Trp-His, Met-His, Val-His, His-His, Isoleucine-His, Hydroxyproline-His, Leu-His, Ala-

His, Gly-His, Beta-Alanylhistidine, Pro-His, Carnosine, Anserine, Tyr-Arg, Hydroxylysine-His, His-Hydroxytlysine, Ornithine-His, His-Lys, His-Ornithine and Lys-His.

8. The formulation of claim 1, wherein the drug comprises a polypeptide or a protein.

9. A transdermal electrotransport drug delivery device (10) having a reservoir (26, 28) containing the formulation of claim 1.

10. A transdermal electrotransport drug delivery device (10) having a drug-containing donor reservoir (26, 28) containing the formulation of claim 1.

11. A transdermal electrotransport drug delivery device (10) having a electrolyte-containing counter reservoir (26, 28) containing the formulation of claim 1.

12. A method of buffering an aqueous solution of a drug or an electrolyte used for transdermal electrotransport delivery, comprising buffering the solution with a dipeptide comprising a chain of 2 to 5 amino acids and having an isolectric pH at which the dipeptide carries no net charge, the dipeptide having at least 2 pKa's which are separated by no more than about 3.5 pH units, the solution having a pH which is within about 1.0 pH unit of the isoelectric pH.

13. The method of claim 12, wherein the isoelectric pH of the dipeptide is between about 3 and 10.

14. The method of claim 12, wherein the dipeptide is present in the solution at a concentration of at least about 10 mM.

15. The method of claim 12, wherein the dipeptide contains one or more of His, Tyr, Arg, Cys, Lys, Asp and Glu.

16. The method of claim 12, wherein the dipeptide contains His.

17. The method of claim 12, wherein the dipeptide is Gly-His.

18. The method of claim 12, wherein dipeptide is selected from the group consisting of Asp-Asp, Gly-Asp, Asp-His, Glu-His, His-Glu, His-Asp, Glu-Arg, Glu-Lys, Arg-Glu,, Lys-Glu, Arg-Asp, Lys-Asp, His-Gly, His-Ala, His-Asn, His-Citruline, His-Gln, His-Hydroxyproline, His-Isoleucine, His-Leu, His-Met, His-Phe, His-Pro, His-Ser, His-Thr, His-Trp, His-Tyr, His-Val, Asn-His, Thr-His, Try-His, Gin-His, Phe-His, Ser-His, Citruline-His, Trp-His, Met-His, Val-His, His-His, Isoleucine-His, Hydroxyproline-His, Leu-His, Ala-His, Gly-His, Beta-Alanylhistidine, Pro-His, Carnosine, Anserine, Tyr-Arg, Hydroxylysine-His, His-Hydroxytlysine, Ornithine-His, His-Lys, His-Ornithine and Lys-His.

19. The method of claim 12, wherein the drug comprises a polypeptide or a protein.

20. The method of claim 12, wherein the solution is contained in a reservoir of a transdermal electrotransport drug delivery device.

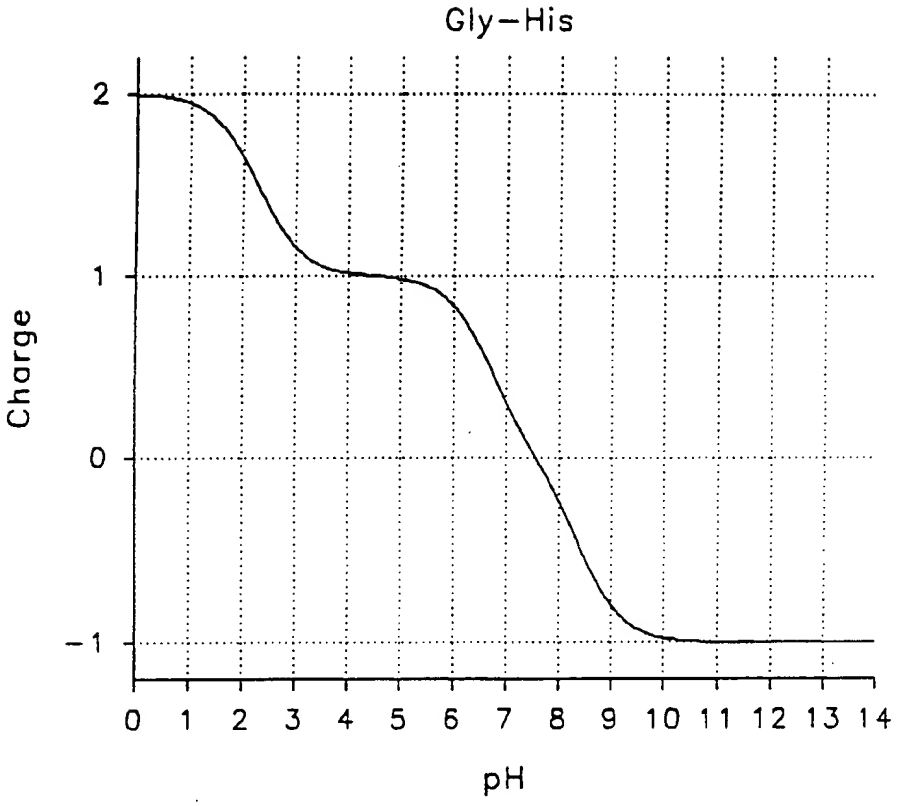


FIG. 1

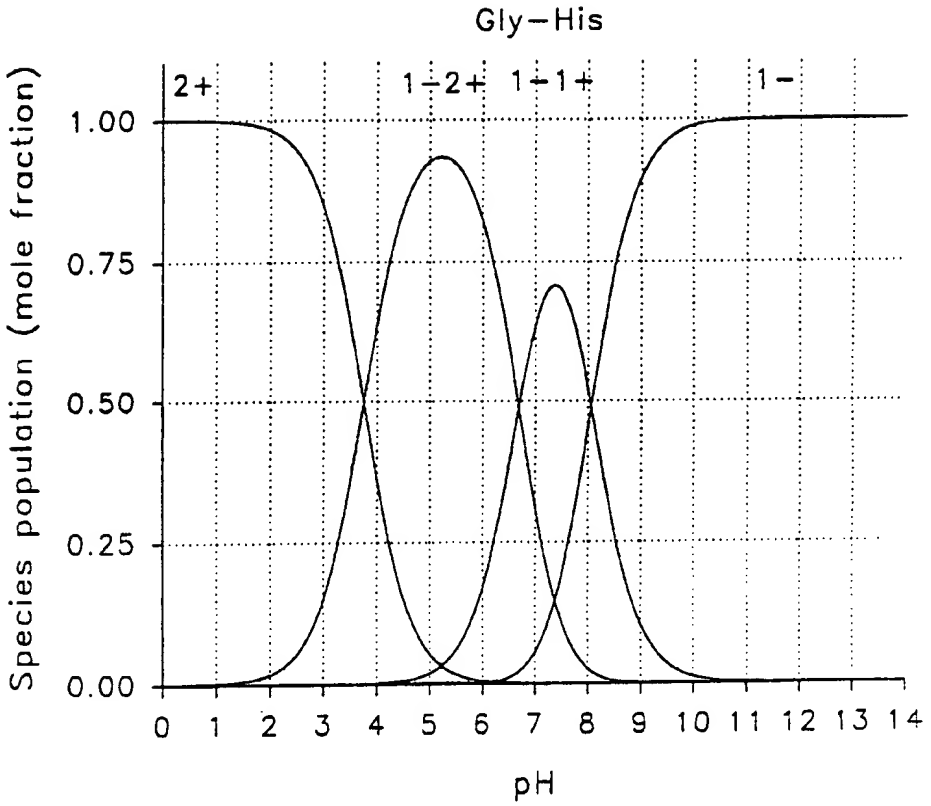

Gly–His
2+
1–2+
1–1+
1–
1.00
0.75
0.50
0.25
0.00
Species population (mole fraction)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
pH

FIG. 2

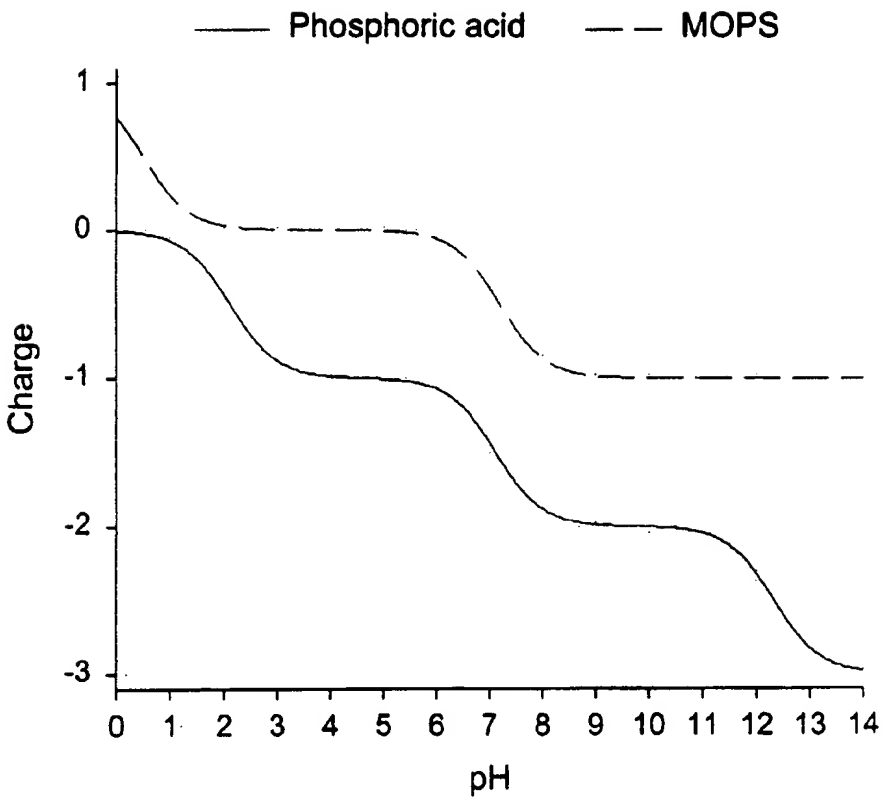

Phosphoric acid
MOPS
Charge
1
0
-1
-2
-3
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
pH

FIG. 3

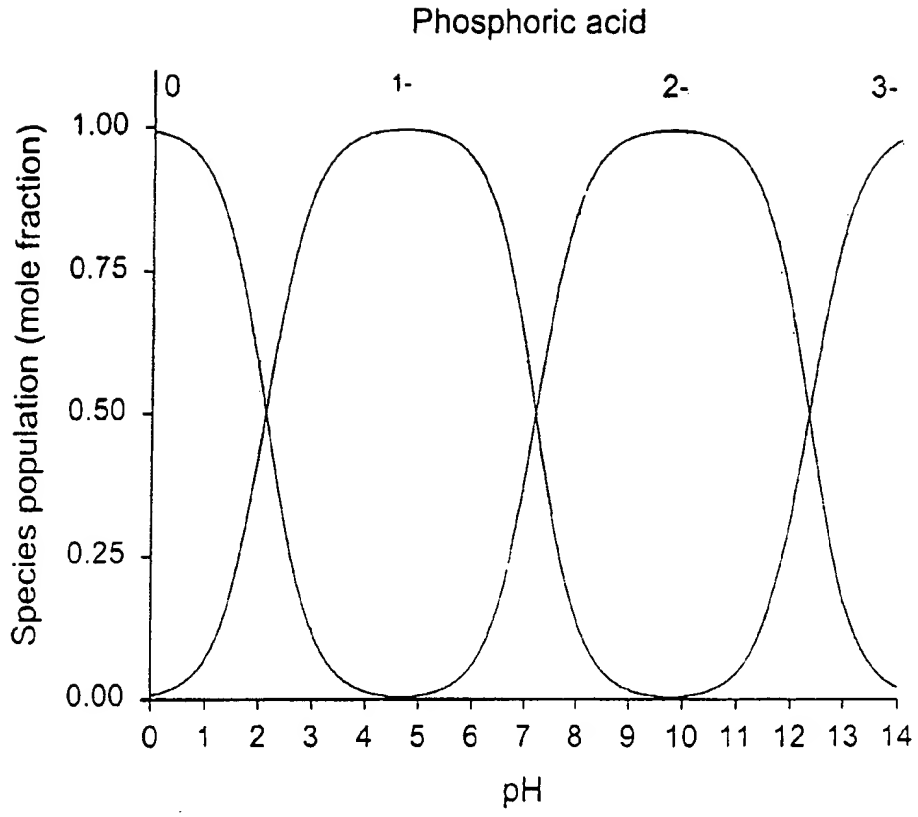

Phosphoric acid
0
1-
2-
3-
1.00
0.75
0.50
0.25
0.00
Species population (mole fraction)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
pH

FIG. 4

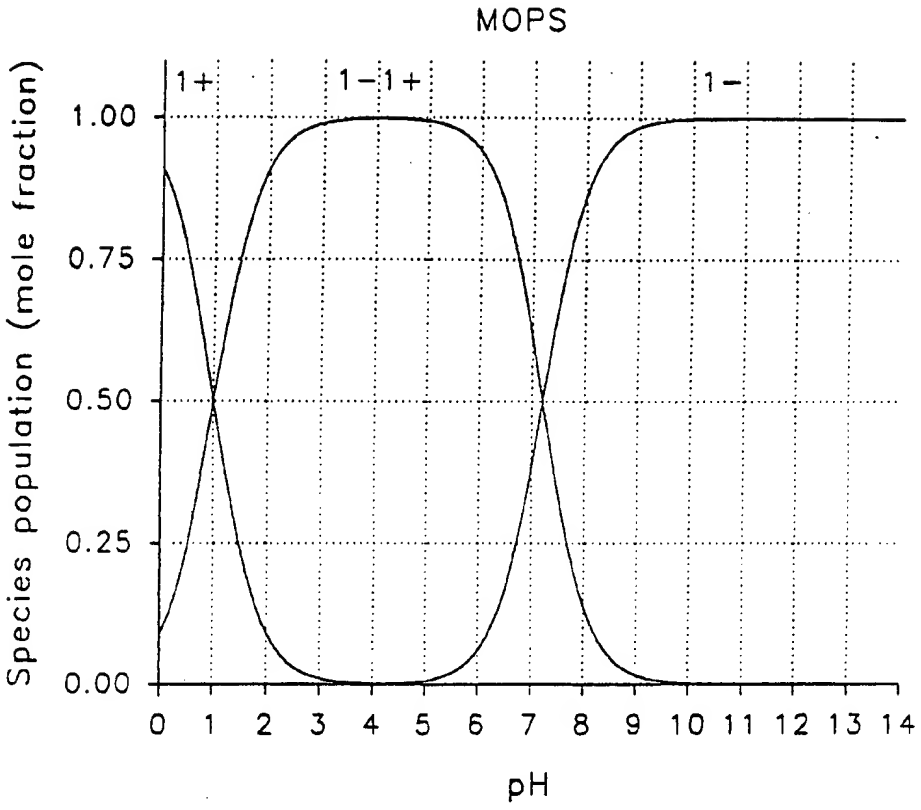

MOPS
1+
1−1+
1−
1.00
0.75
0.50
0.25
0.00
Species population (mole fraction)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
pH

FIG. 5

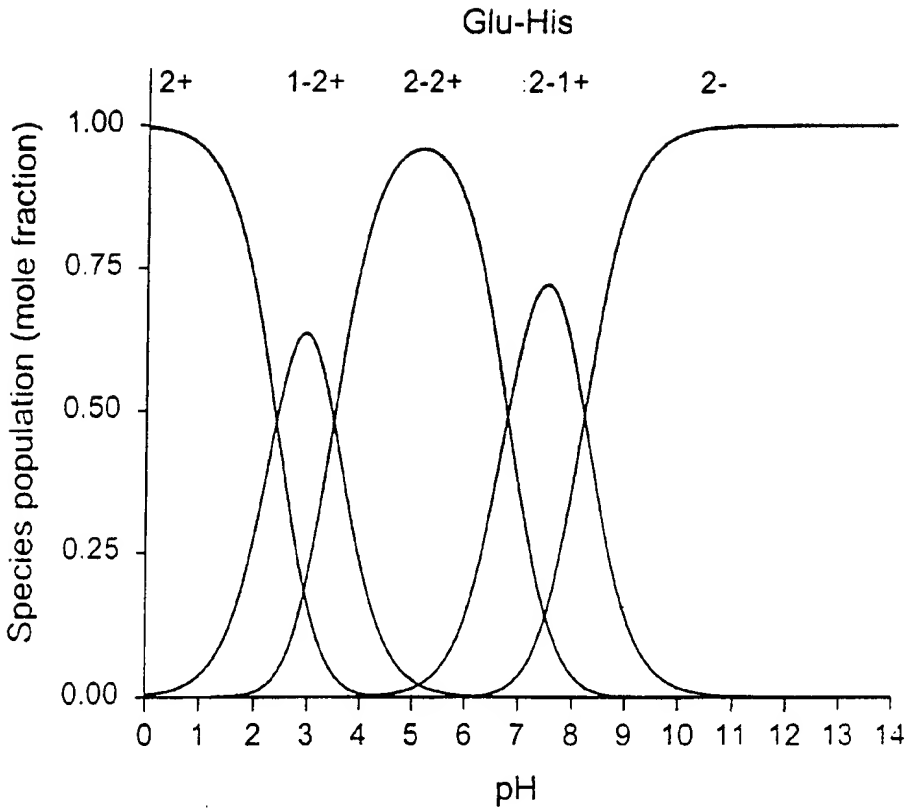

Glu-His
2+
1-2+
2-2+
2-1+
2-
1.00
0.75
0.50
0.25
0.00
Species population (mole fraction)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
pH

FIG. 6

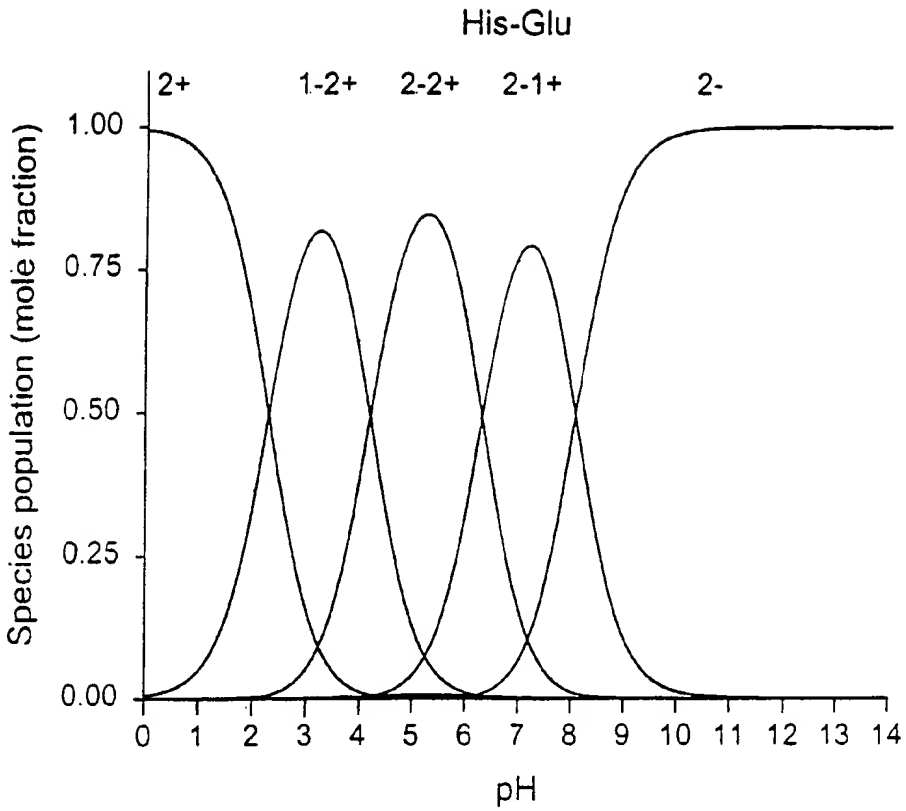

His-Glu
2+
1-2+
2-2+
2-1+
2-
1.00
0.75
0.50
0.25
0.00
Species population (mole fraction)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
pH

FIG. 7

FIG. 8

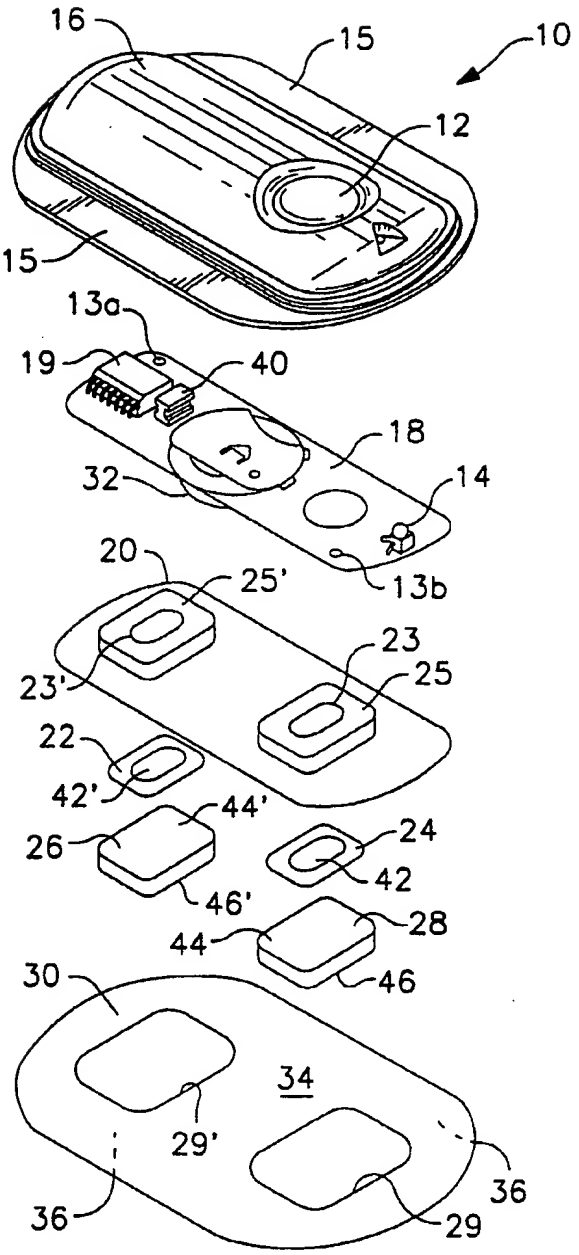

16
15
10
12
15
13a
19
40
18
32
14
13b
20
25'
23'
23
25
22
42'
44'
26
24
42
46'
28
44
46
30
34
29'
36
36
29

FIG. 9

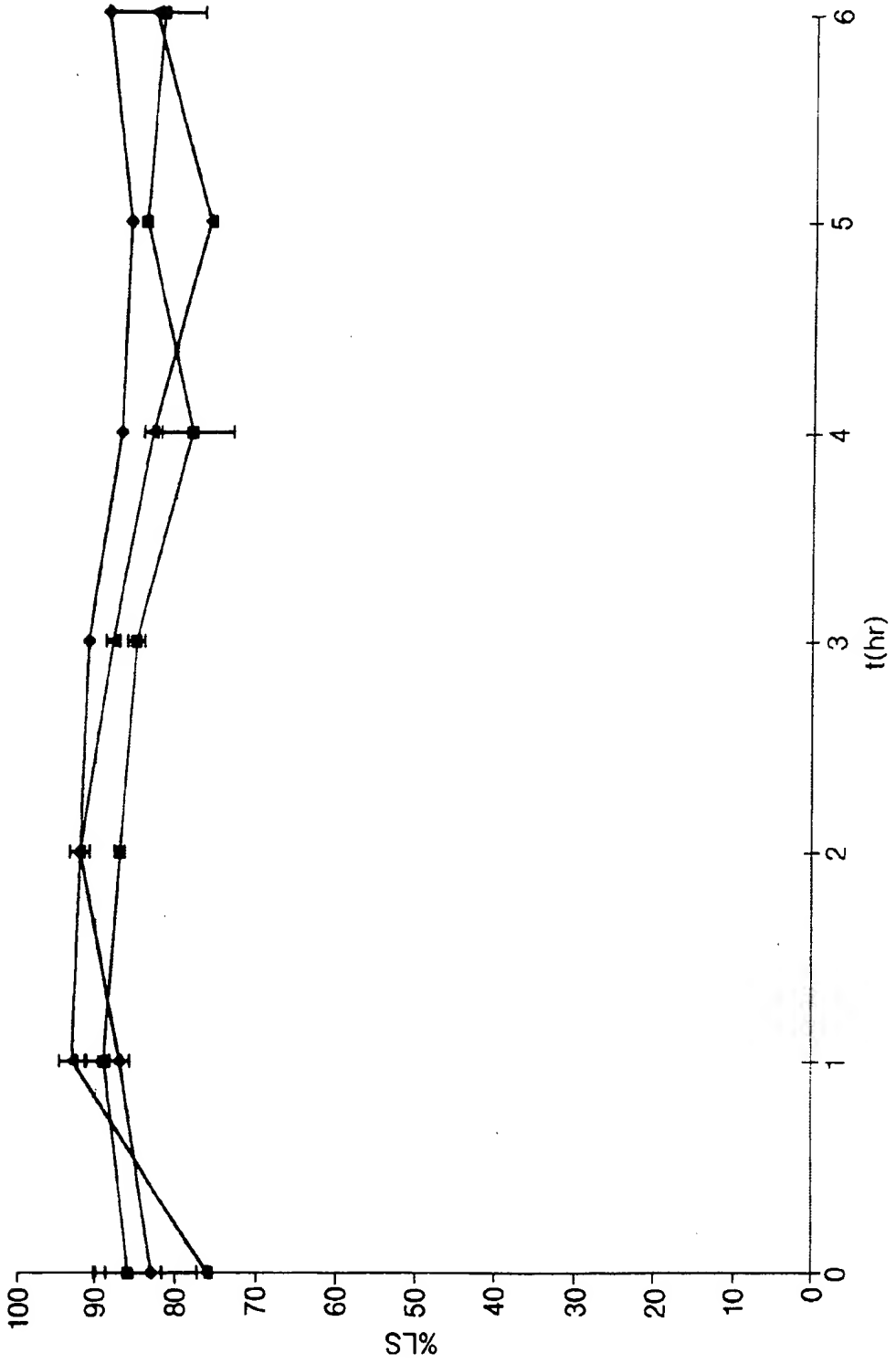
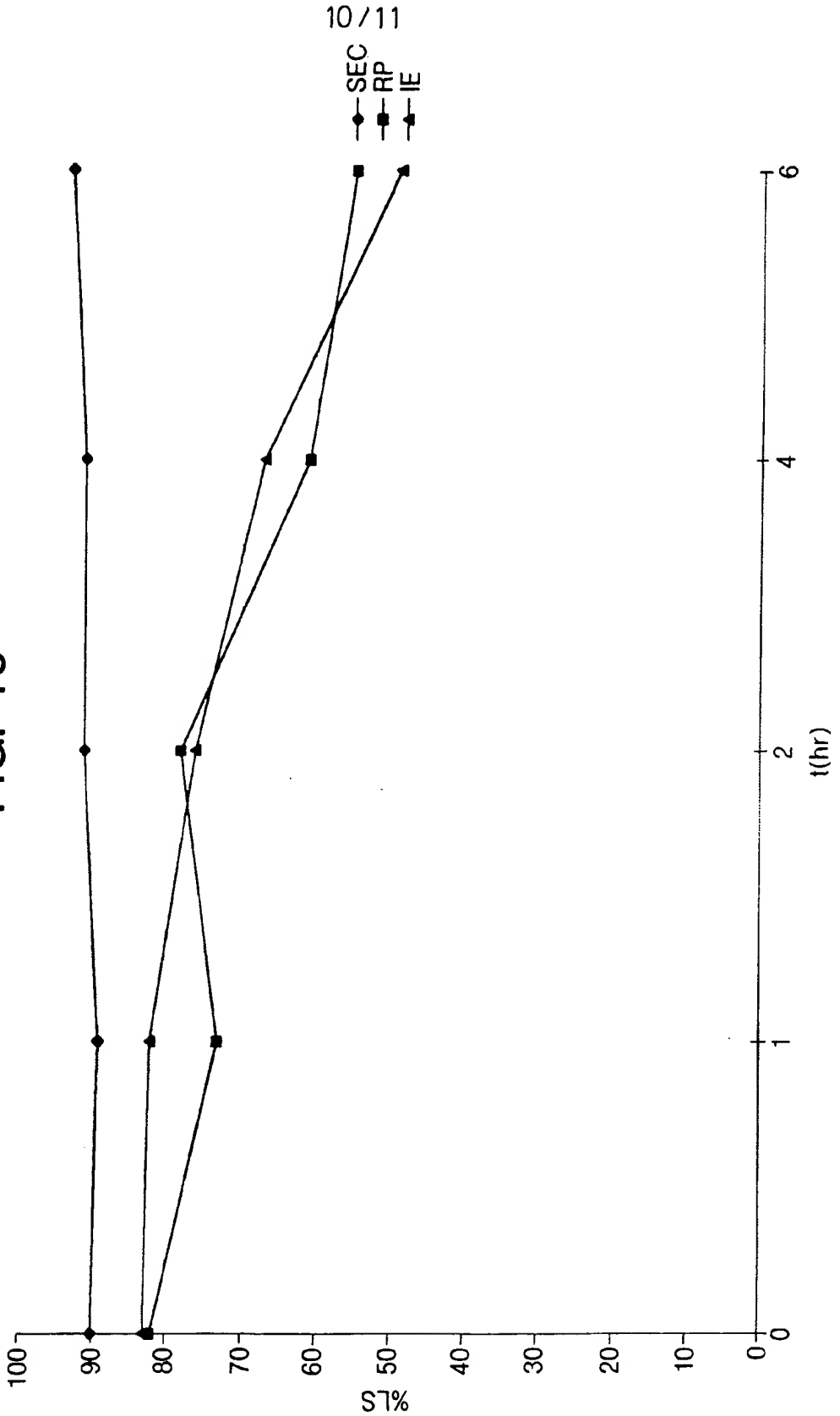


FIG. 10



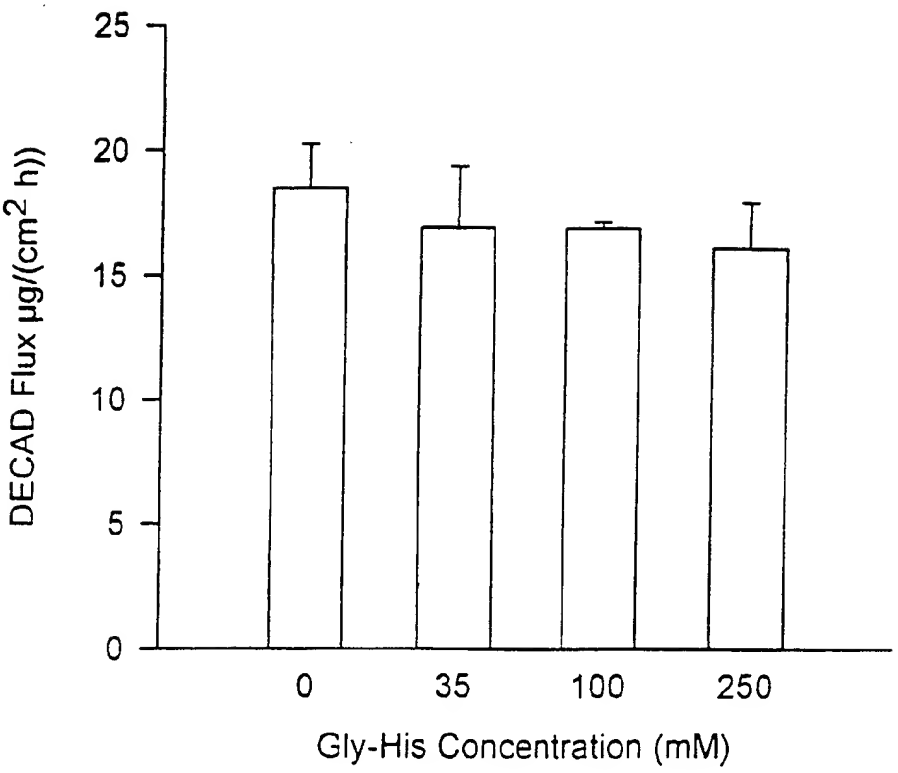

25
20
15
10
5
0
DECAD Flux µg/(cm2 h))
0
35
100
250
Gly-His Concentration (mM)

FIG. 11